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THE PRODUCTION OF GLASS : POSSIBILITY OF SMALL SCALE PRODUCTION

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THE PRODUCTION OF GLASS - POSSIBILITY OF SMALL SCALE PRODUCTION

by

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1. There are six main types of glass used in building:-

(a) Sheet or window glass
(b) Plate glass
(c) Float glass
(d) Patterned glasses - including cathedral and rolled and wired glass
(e) Hollow glass blocks
(f) Opaque cladding glasses for cladding the outside of buildings

2. The basic glass for all these forms is the same although there may be minor modifications to the chemical composition to produce coloured or opaque glasses. Figure (I) shows in schematic form the process of manufacture starting from the common tank furnace.

3. Although the tank furnace is of similar appearance for all the products, in fact it may be quite different in design and in operation when used for the different products because of the quality or load requirements of the particular glass.

4. For instance, in the manufacture of Plate or Float glass a very high standard both for planimetry and absence of faults within the glass, such as bubble, is required. In Rolled Plate and other obscured glasses the quality requirements are much lower and the furnace is run in quite a different way.

5. However, for descriptive purposes we can assume that all the products are produced from the same furnace.

6. The Figure shows the flow of raw materials to the factory. These materials are stored in silos in quantities large enough to ensure adequate supplies to cover any delays in delivery due to transport difficulties, seasonal working in the raw materials quarries or any other reason.

7. From the silos the materials are weighed and fed to a mixer (B) and after thorough mixing transported and fed into the filling end of the tank furnace (C) where they are melted and fined and cooled to the right temperature for rolling, drawing and pressing, as the case may be.

8. COMPOSITION:

The typical chemical compositions for the glasses are as follows:-

	SHEET	PLATE	ROLLED	PRESSED
SiO_2	72.0 - 73.0%	70.0 - 72.6%	71.5 - 72.7%	72.4%
CaO	7.0 - 8.4%	9.6 - 12.1%	8.8 - 10.1%	7.4%
MgO	3.7 - 4.6%	2.0 - 3.2%	2.4 - 3.9%	2.9%
Al_2O_3	0.7 - 1.5%	0.1 - 1.1%	1.1 - 1.3%	1.9%
Na_2O } K_2O }	13.0 - 14.5%	13.4 - 13.8%	13.5 - 13.8%	14.8%
Fe_2O_3	0.08 - 0.16%	0.05 - 0.13%	0.13 - 0.16%	0.065%

9. RAW MATERIALS:

Careful chemical and physical control of the raw materials to specification is very important and a careful watch must be kept for contamination by such materials as chromium and iron, and the moisture content of the materials should also be held at a low and consistent figure - a figure of 4% in the mixed batch is quite commonly used.

10. WEIGHING & MIXING:

It is, of course, important to have a good accurate weighing machine which is regularly checked, and a really good mixer. Various types of mixers are available but those mainly used have been designed originally for mixing concrete or mortar.

11. TRANSPORT OF MIXED BATCH:

The thoroughly mixed raw materials, known as batch, are transferred to the furnace by some means which will not shake them in such a way as to cause segregation. Skip transport is probably most common and the skip will take the whole of the contents of the mixer.

12. The mixed batch is fed together with broken glass or "cullet" into the furnace in a variety of ways. There are proprietary makes of mechanical feeder or the batch may be emptied direct from the skip onto the filling pocket of the furnace.

13. FUELS FOR HEATING THE FURNACES:

Three systems of heating glass furnaces are now common - producer gas made within the factory from coal; heavy oil; natural gas. Electrical is also sometimes used.

14. Because about half a ton of coal or its equivalent is used for every ton of glass melted, the most important factor in deciding which fuel to use is the cost. This should be calculated in terms of the cost per therm at the furnace valve or port. Once this has been calculated the choice is almost made but oil or natural gas have some inherent advantages due to

the consistency of their composition and their ease of handling. Price being equal there is little doubt that the vast majority of glass manufacturers would choose either natural gas or oil rather than coal.

15. THE FURNACE:

The Figure shows a typical glass melting furnace.

16. The batch is fed in at E, passes out into the melting end of the furnace F where it is heated by flames from the port I and then gradually flows down the furnace to the "working end" G and is cooled down to the appropriate temperature for drawing, rolling or pressing at H.

17. The construction of the furnace will consist of a bath to contain the molten glass, side walls and roof above the glass and combustion space, the firing ports, regenerators and associated flues. These various ports are built of different types of refractory material. The sides of the bath at the melt end will be built, almost always, from blocks of electrocast refractory material of the best grade. Further down in the cooler parts of the bath and on the bottom of the bath a less refractory material can be used, either a lower quality and cheaper electrocast refractory or a burned clay block. These parts of the furnace wear much less rapidly, mainly due to the lower temperature of the glass, but also due to the fact that the blocks at the melting end are in contact with the melting batch which is very corrosive.

18. The roof of the furnace and the side walls above the glass level are built from very high quality silica bricks. Not only is chemical composition important but also dimensional accuracy.

19. SHEET OR WINDOW GLASS:

Glass made by this process is used in very large quantities in most countries of the world, and though there is at the moment probably more capacity than is necessary in the world, with the increase in building, which is going on everywhere with more glass being used in these buildings, any surplus capacity is likely to be fully used in the near future, at least temporarily.

20. Sheet Glass has visible distortion, particularly when viewed from a fairly acute angle and for this reason is not fully suitable for good quality mirrors or for glazing of windows such as shop windows or large so-called "picture windows" in houses.

21. It is a much cheaper glass to produce in the thickness normally used for house glazing and for this reason is used almost exclusively in that field.

22. Glass is melted in the continuous tank furnace previously described and flows into a kiln from which it is drawn by one of three processes, the Fourcault, the P.P.G. or the L.O.F. process.

23. In the Fourcault process a large refractory clay piece called a debiteuse is pressed down into the glass so that glass flows up through a slot in the middle. Initially this glass is carried up to the asbestos covered rollers in the annealing tower by a steel framework and the initial glass sheet draws behind it a continuous sheet of glass, and this process continues, the glass being cut into suitable sizes at the top of the annealing tower and taken to the warehouse for cutting into customers' sizes.

24. In all the sheet processes the main difficulty in getting the process to run is to prevent the wasting inwards of the sheet under the forces of surface tension. If this is allowed to happen the width of the sheet will narrow rapidly from say 100" wide to only a few inches wide in time of only a few minutes. Various devices are employed to stop this wasting, all depending on chilling the edge of the glass so that it sets solid quite rapidly and cannot thereafter become narrower. In the Fourcault process this is achieved at the debiteuse itself.

25. In the case of the P.P.G. process, there is a piece of claywork below the surface of the glass which can be of much the same shape as the debiteuse, and acts as a stabiliser of the position of the sheet. In this process the edges are held by water cooled edge rollers which grip about one inch of the edge of the sheet and at the same time cool the edge.

26. In both the Fourcault and the P.P.G. processes the sheet iscarried up vertically through a metal tower which acts as an annealing chamber. At the top of the tower some 28 feet above the furnace level the glass is cut off from the vertical ribbon, its edges which are both thicker than the rest of the sheet and also can be marred by contact with the edge rollers, are cut off and the remaining sheet is either despatched direct to the customer or is sent to a warehouse for inspection and cutting to smaller sizes.

27. The third sheet glass process is the L.O.F. Here the sheet is initially drawn vertically, much in the same way as in the P.P.G. process, but after rising only a few feet it is bent, while still plastic, over a special roller into the horizontal position and is then carried down a horizontal lehr as in the Plate or Float process.

28. Plate Glass:

The Figure shows an outline of this process. Glass from the melting furnace which has been cooled down in the working end of the furnace and in the canal is passed between water cooled steel rollers which produce a ribbon about 100" wide and normally rather more than 1/4" thick. This ribbon is conveyed on steel rollers into the annealing chamber or lehr where during its passage through the lehr, it is cooled down at a carefully controlled rate to ensure that it is free from strain when it emerges from the lehr.

29. table Up to the end of the lehr the process is identical whether the continuous grinding machine is used or the twin grinder. Taking the twin grinder process first; the ribbon is inspected for any faults which could cause trouble in the grinder, and the continuousribbon is passed into the grinder and ground between top and bottom grinding heads, being supported

during passage between adjacent heads by rollers.

30. In all grinding processes the purpose of the first and second heads is to remove enough glass to produce a flat plate. For this purpose rapid glass removal is necessary and coarse sand is used. The resulting surface is flat but also full of coarse pits from the coarse sand. These coarse pits have themselves to be removed by smaller sand grains and this process continues until a fine textured ground surface or "smooth" is produced. In order to achieve this smooth it has been found that a minimum of about twelve heads is needed not only to produce the necessary fineness of smooth but also this number of heads is required to create the right amount of small particles of sand needed in the head at the exit end of the machine.

31. There are two methods of dealing with the ribbon of ground glass. Firstly, it may be passed directly to a twin polisher where top and bottom surfaces are polished simultaneously or the ribbon may be cut into suitable lengths and stored ready for polishing on a continuous table polishing machine operating at high speeds.

32. Both systems have been used but it is often felt that it is better to break the processing at the end of the grinding plant so that there is more flexibility in the polishing plant, and glass stocking problems are reduced.

33. As was said earlier the glass can be treated in a different way at the end of the lehr and can be sent to the continuous grinding and polishing machine. This is an older process but is still very efficient and for some purposes is more flexible than the twin process.

34. In the plate glass plant feeding the continuous table machine the glass ribbon is cut at the end of the lehr and the so-called rough cast blanks which may be about 170" long x 100" wide are stored in a stock room until required by the continuous table polishing machine.

35. This machine consists of a series of abutting cast iron tables which move over mechanical slides in a horizontal direction. As each table reaches the end of the slide it is transported back to the beginning of the machine either on a track beside the machine or in a tunnel under the machine and is then put back into the train of abutting tables.

36. The glass laid on the tables passes under a series of grinding heads - again about twelve in number - is inspected in the centre of the machine while still on the tables and after emerging from the grinding heads and before entering the polishing section of the machine. Again there are a large number of polishing heads - usually upwards of twelve. The heads are faced with felt and a slurry of rouge and water is used as a polishing medium.

37. After emerging from the polishing heads the plates of glass are lifted off the tables and returned to the beginning of the machine where they are placed polished face downwards so that the other face can be ground and polished.

38. This process again needs a large production, though it is sometimes operated at rather lower outputs than the twin grinder. As explained before in connection with the twin grinder, at least twelve grinding heads are needed in order to carry out the required steps of reducing the size of sand grains and hence the depth of pit remaining in the surface of the ground glass, and also this number of heads is required to produce the required amount of sand of different grades for the grinding process. These same reasons make for a large continuous table machine and for a large output from the machine.

39. It is only possible to work out the economic size of unit when one knows all the factors in any particular country, the cost of materials, labour power and transport, for instance, but in general it can be said that the market demand for plate glass must reach 20-25 million square feet per year before a viable unit can be operated except behind very high tariff walls and, of course, at the expense of the consumer who must pay much above world prices for the plate glass made at low output and high cost.

40. FLOAT GLASS:

This is a new process. The product Float glass was introduced to the market in 1959. It is a glass which is now used interchangeably with plate for such purposes as a motor car windscreen, mirrors and good glazing. It is steadily capturing more and more of the plate glass market.

41. The Figure shows the outline of this process. Again glass is made in a continuous tank furnace, as in the case of plate glass, but before passing into the lehr the glass is passed onto a bath of molten metal. Here under the influence of physical forces it becomes flat and attains a fire-finished surface. From the bath it is taken in the form of a continuous ribbon into the lehr, where it is annealed and on emerging it is ready for cutting up and despatching to the customer, without any further processing such as grinding and polishing.

42. This process is still very young. Float glass is manufactured by the inventors in England, and has been licensed by them to one company in the United States, and it is rather too early to discuss the process in detail or consider the possibilities of this process for operation on a small scale.

43. PATTERNED GLASSES:

These are made from a tank furnace usually somewhat smaller in size than the furnaces for plate or sheet glass and are rolled in the same way as plate is rolled. However, the rollers of the rolling machine are engraved so that they impress a pattern on the glass being rolled between them. This process is also used for making wired glass, the wire being inserted in the middle of the sheet of glass during the rolling process.

44. HOLLOW GLASS BLOCKS:

These are made by pressing techniques and space does not permit a description of the process, which in any case is not likely to be of much interest in this context because of the fairly low demand in most countries.

Broadly there are two types of glass of this sort, self-coloured opaque glasses made as opals with colouring material added at the melting stage and, secondly, rolled glasses which have been subsequently coloured by a process rather similar to vitreous enamelling. This later type is frequently heat treated to give increased strength and resistance to thermal shock. This is important particularly where the glass is to be used in sunny climates and where the edge is contained in a frame. Under these conditions the edges covered by the glazing bars will not be heated as much as the central area of the glass, with result that the edges will be put into tension, in which condition any slight flaw in the edge caused, for instance, by the cutting process, will tend to start a break which will travel across the whole of the plate of glass.

46. I have dealt briefly with the variety of processes which are used in the flat glass industry to supply the glass to the building industry, but I have said little about the feasibility of using any of these processes on a small scale except where there were limitations inherent in the techniques of the process.

47. First of all glass is a cheap material; the main components in the cost are labour, fuel and raw materials as well as the capital charge for the plant. The only element of cost that I have mentioned which varies directly with production is the cost of raw materials. All the others drop slightly with reduced production but not nearly in proportion to the output. The easiest way of reducing the cost of glass is to increase the output of the unit and conversely the way of making expensive glass is to reduce the output of the unit and it is not long before the cost of manufacture is excessively high, and the manufacturing process becomes uneconomic.

48. Running through the processes I have mentioned, we can get some idea of the minimum yearly output that could justify a small unit. If this market exists a unit can be built and will operate at a reasonable cost, but probably not at a cost which would compete in open markets with exports from the main manufacturing countries.

PROCESS	MINIMUM YEARLY QUANTITY SQ.FT.
SHEET (Double strength basis)	20,000,000
PLATE	20,000,000
FLOAT	NOT YET AVAILABLE
ROLLED	15,000,000
GLASS BLOCKS (when made in conjunction with other pressed articles	100,000 Units
CLADDING GLASSES	2,000,000

49. If these markets are available then a case can be made out, at least for a cost exercise of manufacture if the raw materials mentioned in the first part of my paper are readily available at reasonable prices and of adequate quality.

50. It should be remembered, however, that for a variable time at the start up of the plant there may well be periods of high breakage and low quality. This period may well last for a considerable time, particularly if no really expert operating help is available. Scientific papers and written advice are very useful in their way but they are no substitute for the skill and experience of men who have spent years in operating the furnaces and machines. Sometimes experts offer their services to design, instal and start up glass plants. Anyone considering using their services should make absolutely certain that these experts have had real practical experience of running the type of glass plant they are prepared to start.

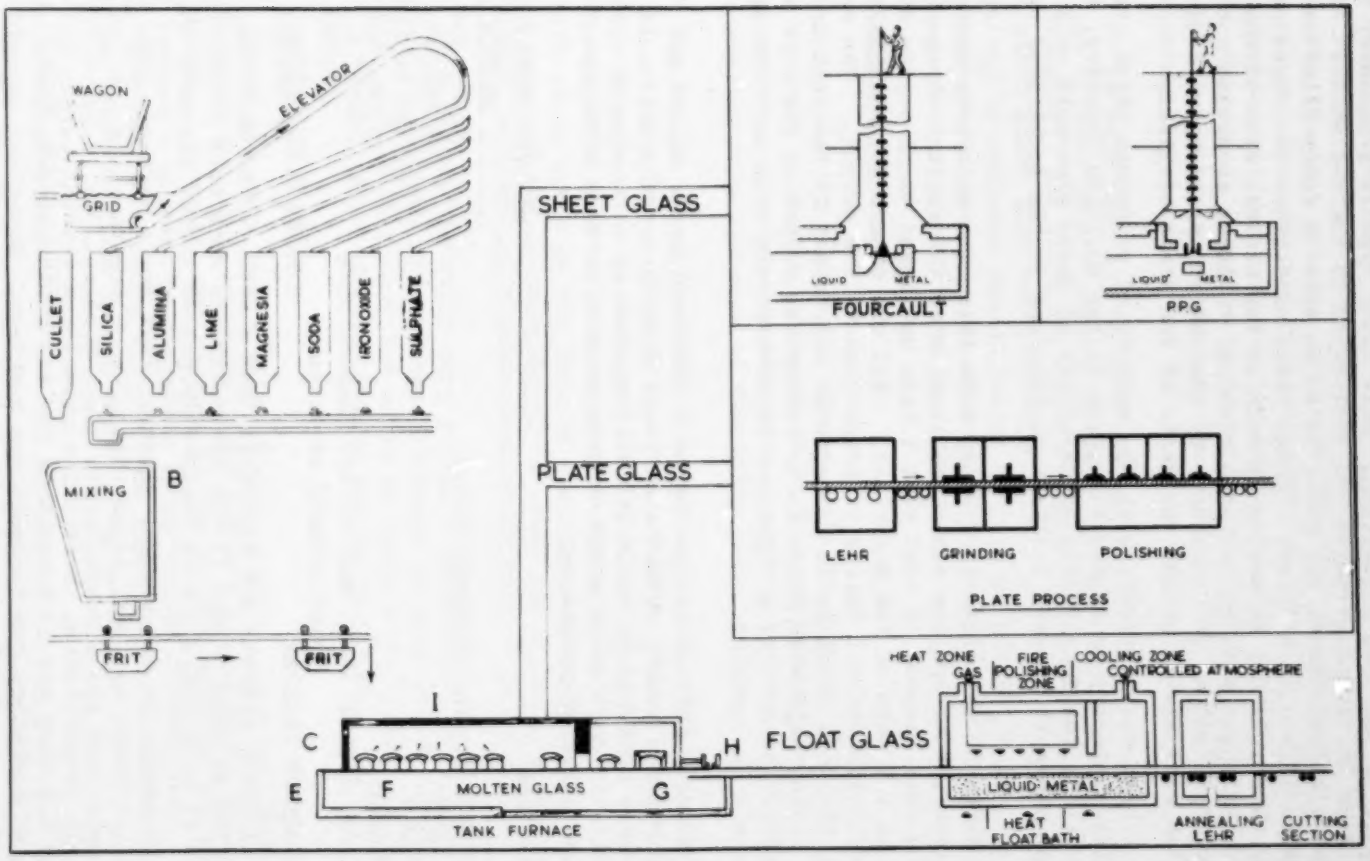
WAGON
ELEVATOR
GRID
CULLET
SILICA
ALUMINA
LIME
MAGNESIA
SODA
IRONOXIDE
SULPHATE
MIXING
B
FRIT
FRIT
SHEET GLASS
PLATE GLASS
LIQUID METAL
FOURCAULT
LIQUID METAL
PPG
LEHR
GRINDING
POLISHING
PLATE PROCESS
HEAT ZONE GAS
FIRE POLISHING ZONE
COOLING ZONE CONTROLLED ATMOSPHERE
I
C
H
FLOAT GLASS
E
F
MOLTEN GLASS
G
TANK FURNACE
LIQUID METAL
HEAT FLOAT BATH
ANNEALING LEHR
CUTTING SECTION

Fig. 1

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